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Mismeasuring Long Run Growth: The Bias from Spliced National Accounts

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Mismeasuring Long Run Growth.

The Bias from Spliced National Accounts[1]

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Abstract

Comparisons of economic performance over space and time largely depend on how statistical evidence from national accounts and historical estimates are spliced. To allow for changes in relative prices, GDP benchmark years in national accounts are periodically replaced with new and more recent ones. Thus, a homogeneous long-run GDP series requires linking different temporal segments of national accounts. The choice of the splicing procedure may result in substantial differences in GDP levels and growth, particularly as an economy undergoes deep structural transformation. An inadequate splicing may result in a serious bias in the measurement of GDP levels and growth rates. Alternative splicing solutions are discussed in this paper for the particular case of Spain, a fast growing country in the second half of the twentieth century. It is concluded that the usual linking procedure, *retropolation*, has serious flows as it tends to bias GDP levels upwards and, consequently, to underestimate growth rates, especially for developing countries experiencing structural change. An alternative *interpolation* procedure is proposed.

Keywords: growth measurement, splicing GDP, historical national accounts, Spain

JEL Classification: C82, E01, N13, O47

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[1] This paper has been written to honour the memory of Angus Maddison. Earlier versions of the paper were presented at the "Maddison Memorial Conference", International Institute of Social History, Amsterdam, November 2010, and the International Economic History Association Congress, Helsinki, August 2006. I acknowledge participants and, especially, Bart van Ark and Albert Carreras, for their remarks and suggestions. I have also benefited from exchanges with Ángel de la Fuente, Antonio Díaz Ballesteros, and David Taguas (+).

Last April it was made public that Nigeria's GDP figures for 2013 had been revised upwards by 89 per cent, as the base year for its calculation was brought forward from 1990 to 2010 (Financial Times April 7, 2014). As a result, Nigeria became the largest economy in Sub Saharan Africa. Though spectacular, this is not an exceptional case. Ghana (2010), Argentina's (1993) or Italy's (1987) also experienced dramatic upward revisions of their GDP. How should this revision affect GDP time series? How would the relative position of the country be affected? Should the existing historical series be re-scaled in the same proportion? Or should the gap between the new and the previous figures for 2013 be distributed over time, i.e., over 1990 and 2013?

Comparisons of GDP levels and growth rates across countries and over time attract interest beyond academic borders as they have implications for current policy debates. The expansion of the so-called 'historical national accounts', namely, the outcome of independent research on national accounts for the 'pre-statistical era', has been the response to a rising demand for long run GDP series. The usual procedure to derive comparable real per capita income time series starts from a recent benchmark year estimate of GDP per head, adjusted for its purchasing power, that is, then, projected backwards with volume series derived from official and historical national accounts.

Angus Maddison (1995, 2010) pioneered the efforts to provide comparable levels of real GDP per head, expressed in 1990 Geary-Khamis international dollars (derived from the International Comparisons Programme [ICP] estimates for 1990) and stimulated the reconstruction of historical national accounts (HNA).[2] Recently, the Penn Tables 8.0 also derived series at constant prices for 1950-2011 by projecting estimates for a newer ICP benchmark year, 2005, with real GDP growth rates obtained from national accounts (Feenstra et al., 2013).

Along with the construction of comparable benchmark estimates, deriving consistent long time series presents a serious challenge. Official national accounts are

[2] Actually, Maddison made earlier attempts to produce comparable estimates for real product per head expressed in US relative prices derived from Paasche PPPs (Maddison, 1982, 1991a). Currently, the Maddison Project aims at carrying forward his project (Bolt and van Zanden, 2014).

usually available from mid-twentieth century onwards, but often only for the latest decades. Hence, the output of national accounts needs to be spliced with historical national accounts. Furthermore, official national accounts are only constructed in a homogeneous way for short periods.

Thus, when a homogeneous long-run GDP series is required, various sets of national accounts using different benchmark years and often constructed with dissimilar methodologies need to be spliced. Applied economists and national accountants hardly pay much attention to how the splicing procedure may affect GDP levels for the past and their main concern is the consistency of the rates of variation between the 'old' and the 'new' series. Economic historians worry, instead, about the reliability of the historical series, but accept the output of countries' statistical offices at face value. However, the alternative choice of splicing procedures to derive a single GDP series may result in substantial differences in levels and growth rates and, hence, in significant biases in the assessment of economic performance over time.

Maddison (1991b) was an exception and addressed the splicing issue while researching on Italy's long-term economic performance. He found that an inadequate splicing would introduce a bias in both the level of GDP and in its growth rate. Unfortunately, Maddison's warning about a serious risk of mismeasuring growth over the long run has not been paid enough attention.[3]

It is my purpose to call attention to the splicing issue and to warn about its pervasive impact. In this paper I am using the case of Spain during the second half of the twentieth century as an illustration. The Spanish experience provides a relevant example of the risks involved in conventional splicing for a country that has undergone a deep and fast structural transformation. For this type of countries it can be hypothesized that were national accounts properly spliced, their initial levels would be revised downwards and,

[3] It is surprising the neglect of the splicing problem in the revisions of Italian historical national accounts, whose authors are more interested in pointing out at the discrepancies between the new series and Maddison's estimates (Baffigi, 2013; Brunetti et al., 2011).

hence, their growth rates increased. The available historical national accounts of developing countries would be, hence, seriously affected.[4]

Alternative splicing procedures

National accounts rely on complete information on quantities and prices in order to compute GDP for a single benchmark year, which is, then, extrapolated forward on the basis of limited information for a sample of goods and services. To allow for changes in relative prices and, thus, to avoid that forward projections of the current benchmark become non representative, national accountants periodically replace the current benchmark with a new and closer GDP benchmark. The new benchmark is constructed, in part, with different sources and computation methods.[5] Often far from negligible differences in the new benchmark year between 'new' and 'old' national accounts stem from statistical (sources and estimation procedures) and conceptual (definitions and classifications) bases. Once a new benchmark has been introduced, newly available statistical evidence would not be taken on board to avoid a discontinuity in the existing series (Uriel, 1986). Thus, the coverage of new economic activities partly explains the discrepancy between the new and old series. As a result, a problem of consistency between the new and old national account series emerges.

Is there a solution to this inconsistency problem? The obvious option would be computing GDP for the years covered by the old benchmark with the same sources and procedures employed in the construction of the new benchmark. However, this option is beyond the resources of an independent researcher. The challenge is, then, establishing the extent to which conceptual and technical innovations in the new benchmark series hint at a measurement error in the old benchmark series. In particular, whether the

[4] See Jerven (2013) for a detailed discussion of the problems affecting developing countries' national accounts.

[5] Improving the comprehensiveness, reliability and comparability of national accounts estimates through the use of new statistical sources, the inclusion of new concepts, and the adoption of new computation procedures are usually the technical reasons provided by national statistical offices for their periodical revisions of national accounts' benchmarks.

discrepancy in the overlapping year between the new benchmark (in which GDP is estimated with 'complete' information) and the old benchmark series (in which reduced information on quantities and prices is used to project forward the 'complete' information estimate from its initial year) results from a measurement error in the old benchmark's initial year estimate.

A simple solution, widely used by national accountants (and implicitly accepted in international comparisons), is the *backward projection, or retropolation,* approach, that accepts the reference level provided by the most recent benchmark estimate (Y_T) and re-scales the earlier benchmark series (X_t) with the ratio between the new and the old series for the year (T) at which the two series overlap (Y_T/X_T).

$$Y^R_t = (Y_T / X_T) * X_t \qquad \text{for } 0 \leq t \leq T \qquad \text{(I)}$$

Underlying this procedure is the implicit assumption of an error level in the old benchmark's series whose relative size is constant over time.[6] In other words, no error is assumed to exist in the old series' rates of variation that are, hence, retained in the spliced series Y^R_t (de la Fuente Moreno, 2014). Official national accountants have favoured this procedure of linking national accounts series on the grounds that it preserves the earlier benchmark's rates of variation.[7] It is worth noting that the *retropolation* approach produces a hybrid result in which levels computed at a given set of relative prices are projected backwards with growth rates obtained from an earlier set of relative prices.

Usually the most recent benchmark provides a higher GDP level for the overlapping year, as its coverage of economic activities is wider. Thus, the backwards projection of the new benchmark GDP level with the available growth rates -computed at the previous benchmark's relative prices- implies a systematic upwards revision of GDP levels for earlier years.[8] This one-sided upward revision effect on the levels of spliced GDP series is

[6] Were this approach accepted in the case of Nigeria presented above, the historical series would be systematically re-scaled by 89 per cent.

[7] For the case of Spain, cf. Uriel (1986), Corrales and Taguas (1991), INE (1992), Uriel, Moltó and Cucarella (2000).

[8] This linkage procedure helps to understand the one-sided upward revisions Boskin (2000) finds in US national accounts.

hardly noticeable when discrepancies between the new and old benchmarks are small for the overlapping year and the considered time span is short. However, as the time horizon expands and earlier series are re-scaled once and again to match newer ones, the gap tends to deepen significantly.

An alternative to the *backward projection* linkage is provided by the *interpolation* procedure that accepts the levels computed directly for each benchmark-year as the best possible estimates, on the grounds that they have been obtained with 'complete' information on quantities and prices, and distributes the gap or difference between the 'new 'and 'old' benchmark series in the overlapping year *T* at a constant rate over the time span in between the old and new benchmark years.[9]

$$Y^{I}_{t} = Y_{t} * [(Y_{T} / X_{T})^{1/n}]^{t} \qquad \text{for } 0 \leq t \leq T \qquad \text{(II)}$$

Being Y^{I} the revised new series, *Y* e *X* the values pertaining to GDP according to the new and old benchmarks, respectively; *t*, the year considered; *T*, the overlapping year between the old and new benchmarks' series; and *n*, the number of years in between the old (0) and the new benchmark (*T*) dates.

Contrary to the *retropolation* approach, the *interpolation* procedure assumes that the error is generated between the years 0 and *T*. Consequently, it modifies the annual rate of variation between benchmarks (usually upwards) while keeps unaltered the initial level –that of the old benchmark-. As a result, the initial level will be probably lower than the one derived from the *retropolation* approach.[10]

A compromise alternative between these options, a 'mixed splicing', has been proposed by Ángel de la Fuente Moreno (2014). The 'mixed splicing' approach rejects both the view that the error in the old series' benchmark year is zero -as in the *interpolation* approach-, or that it is equal to the error observed at time *T* (that is, the difference between the old and the new series at the new benchmark year) -as in the *retropolation*

[9] Maddison (1991b) presented, as far as I know, the first methodological discussion along these lines and an *interpolation* proposal for the case of Italy.

[10] If, alternatively, the *interpolation* approach were accepted for the case of Nigeria, the historical series (1990-2013) would keep the original level for 1990 and re-scale the 2013 level by 89 per cent, while the 89 per cent gap would be distributed over 1991-2012.

procedure-. Instead, the mixed splicing proposes an intermediate position in which an initial error in the old series, stemming from the insufficient coverage of emerging economic sectors (whose share in GDP increases over time), grows at an increasing rate. The appropriate correction to the growth rate of the original series will be, according to de la Fuente Moreno (2014), an increasing function of a parameter ρ [$0 \leq \rho \leq 1$)] that captures the severity of the initial error. Although this proposal seems most reasonable, the challenge, however, is assigning a value to the parameter ρ. Unfortunately, ρ is an unknown and any suggested value would be arbitrary.[11]

An alternative to the 'mixed splicing' is provided by a modified version of the interpolation approach, in which the gap between the new and old series at the overlapping year is distributed over the old series at a growing rather than at a constant rate. This option is conceptually similar to the 'mixed splicing' -the error in the old series increases as one moves away from its benchmark year (as does the share of expanding economic sectors)-, but easier to implement –it does not require any discretional assumption about the value of the parameter ρ-. In order to do it, a variable weighted geometric average between the old series (X_t) and the r*etropolated* series ($Y^R{}_t$), in which the closest benchmark series gets a larger weight, is computed,

$$Y^A{}_t = (X_t)^{(n-t)/n} * (Y^R{}_t)^{t/n} \qquad \text{for } 0 \leq t \leq T \qquad \text{(III)}$$

Being $Y^A{}_t$ the revised new series, X_t and $Y^R{}_t$ the GDP values corresponding to the old and to the retropolated series (computed with expression (I)), respectively; and n the number of years in between 0 and T.

The main shortcoming of the modified interpolation procedure with regard to de la Fuente's 'mixed splicing' is that no initial error is assigned to the old series' benchmark year.

To sum up, the choice of linkage procedure makes a significant difference for GDP levels and growth rates. When the levels for earlier years are re-scaled upwards with the

[11] De la Fuente Moreno (2014: 116) being aware of the problem suggest an alternative approach in which rather than ρ he employs a parameter H (half-life) "that measures the persistence over time of the measurement error" at the linking point. In my view, this solution is still arbitrary.

retropolation procedure, the country in question becomes retrospectively richer. Alternatively, interpolating each original benchmark tends to raise the economy's rate of growth and, hence, casts a lower initial GDP level. Which method is preferable? A practical answer may be derived from the analysis of Spain's experience, a country that went through a process of deep structural change during the second half of the twentieth century.

How have national accounts been spliced in Spain?

Official estimates of Spain's national accounts (*Contabilidad Nacional de España*, CNE) are available for different benchmarks constructed with different methods and sources.[12] Thus, benchmarks for 1958 (CNE58) and 1964 (CNE64) were derived using OECD criteria, while the European version of the UN system of national accounts (SNA) was used for all the rest (CNE70, CNE80, CNE86, CNE95, CNE2000, CNE2008) (Table 1). In all cases, a detailed set of quantities and prices (derived from the closest input-output table) was employed to compute the level of GDP for the benchmark-year (1958, 1964, 1970, … 2000, 2008).[13] GDP estimates for the following years were derived, then, by extrapolating the benchmark level with quantities and prices for a sample of goods and services. However, this was not the procedure used to derive estimates for earlier years. For example, in order to obtain CNE70 estimates for 1964-1969, rather than computing new GDP series using the same conceptual definitions and sources employed to derive GDP levels for 1970 and henceforth, national accountants projected the new 1970 GDP level (CNE70) backwards with the rates of variation derived from the 1964 benchmark series (CNE64).

The choice of the *retropolation* procedure (expression (I)) was made on the arguable assumption that growth rates originally calculated could not be improved

[12] Series constructed with different benchmarks' prices and quantities are named after the year, e.g., CNE70, that is, *Contabilidad Nacional de España* (National Accounts of Spain) with 1970 as the base-year.

[13] For all these benchmark-years input-output tables are available, except for 1964 and 1986, for which the closest ones are those for 1962 and 1966, and 1985, respectively.

(Corrales and Taguas, 1991). However, such an assumption pays no regard to the unpredictable but significant effects of using a set of relative prices from the old benchmark to project the level of the new benchmark backwards, which is implicit in the choice of the *retropolation* approach. The same backward projection approach was adopted to derive series levels for 1954-1957 in the 1958 benchmark (CNE58), and for 1964-1979 in both the 1980 and the 1986 benchmarks (CNE80 and CNE86).[14] A break in the linkage through *retropolation* of GDP series was introduced in CNE86, when national accounts were spliced using the *interpolation* approach and the GDP differential between CEN86 and CEN80 in 1985 was distributed at a constant rate over the years 1981-1985 using expression (II) (INE, 1992).[15] The same *interpolation* method was also used to distribute the GDP gap between CNE2000 and CNE95 in 2000 – once the latter was adjusted for methodological changes introduced in the new benchmark- over 1996-1999 (INE, 2007), and the gap between CNE2000 and CNE2008 in 2008 over 2001-2007.[16]

INSERT TABLE 1 HERE

The main methodological discontinuity in Spanish national accounts occurred when the SNA substituted for the OECD method in the late 1970s. As Table 2 shows, substantial discrepancies appear between CNE64 (constructed with OECD criteria) and the SEC data sets, while the cumulative effect of re-scaling different sub-series widens the gap over time.[17] In fact, the figure obtained for GDP in 1970 by the cumulative re-scaling from

[14] Such is the approach implicitly supported by Uriel (1986) and Uriel, Moltó, and Cucarella (2000). This procedure has the advantage of being less time consuming and not altering the yearly rates of variation resulting from the 'old' benchmark series.

[15] The National Statistical institute (INE) has never produced a new spliced series of the latest base-year CNE2000 back to 1964, 1970, or 1980. Only spliced series from 1980 onwards are provided by the Quarterly National Accounts but no detailed explanation of the splicing procedure is provided.

[16] According the Spanish Statistical Institute, "The differences between both estimates are due to the statistical changes, and given that information is not available regarding how and at what time they have been generated, it is assumed that this has occurred progressively over time, from the beginning of the previous base" (INE, 2007: 5).

[17] It should be noticed (Table 2) that a significant discrepancy only emerges for the SEC accounts in its latest benchmarks CNE95 and CNE2000.

2008 backwards, that is, by using the r*etropolation* approach, is 24 per cent higher than the one directly computed by CNE70.[18]

INSERT TABLE 2 HERE

Would it be reasonable to expect such an underestimate from a direct GDP calculation on the basis of 'complete' information about quantities and prices of the goods and services, as it was the case of CNE70 computation for 1970 GDP? Can the direct measurement of GDP level at an early benchmark year (i.e., 1970) be really improved through the backward projection of the latest benchmark-year (i.e., CNE2008) with earlier benchmarks' annual rates of variation? These questions are addressed in the next section.

An alternative splicing procedure: the *interpolation* approach

The challenge is to produce an alternative linkage that mitigates the upwards bias introduced in historical GDP levels by the *retropolation* approach. The splicing procedure chosen to derive a single yearly GDP series for late twentieth century Spain has been the revised *interpolation* approach. The resulting estimates will be, then, compared to those derived from the *retropolation* approach.

For the period, 1980-2000, the procedure used was straightforward. I linked the five base-year series available from 1980 onwards (CNE80, CNE86, CNE95, CNE2000, CNE2008) accepting the levels directly computed for each benchmark and distributing the gap for each overlapping year over the time span between each pair of adjacent benchmarks using expression (III). Additive congruence was imposed on supply and demand components.[19]

[18] This percentage increase results from successively multiplying the ratios of adjacent benchmarks at overlapping years, that is, CNE2008/CNE2000 in 2008, CNE2000/CNE95 in 2000, CNE95/CNE85 in 1995, CNE85/CNE80 in 1985, CNE80/CNE70, in 1980, and CNE70/CNE64 in 1970, [0.9997*1.0323*1.0439*1.0112*1.0016*1.1378 = 1.2414] (See Table 2).

[19] By additive congruence is meant that the addition of the different components of a given magnitude (output or expenditure) must be equal to its aggregate value (GDP). This is obtained by distributing, proportionally to their relative weight, the deviations of the addition of the linked components' values from the aggregate magnitude (Cf. Corrales and Taguas, 1991).

As it is in the transition between OECD and SNA methodologies when the larger disparities between adjacent benchmarks series emerge in overlapping years, examining the way OECD (CNE64) and SNA (CNE70) benchmarks were constructed may help to reconcile their differences. Thus, a brief technical interlude is presented prior to discussing the interpolation of earlier benchmark series (CNE1958, CNE1964, and CNE1970).

In pre-1980 official national accounts, annual nominal series of, say, industrial value added was usually obtained through back and forth extrapolation of the benchmark year's gross value added with an index of industrial production that was, then, reflated with a price index for industrial goods. Projecting industrial real value added with an index of industrial production amounts to a single deflation of value added, in which the same price index is used for both output and inputs.[20] However, only if prices for output and intermediate inputs evolve in the same direction and with the same intensity, real value added is accurately represented by an industrial production index. In periods of rapid technological change (or external input price shocks) significant savings of intermediate inputs do take place while relative prices change dramatically, and, hence, the assumption of a parallel evolution of output and input prices does not hold.[21] This description applies well to the 1960s and 1970s, when Spain opened up to foreign technology and competition and suffered the oil shock.[22] Fortunately, alternative estimates of gross value added at constant prices derived through the Laspeyres double deflation method (namely, real gross value added obtained as the difference between output at constant prices and intermediate consumption at constant prices, that is, each of them independently

[20] Cf. Cassing (1996) for a discussion of alternative deflation procedures. See, alternatively, David (1962) and Fenoaltea (1976) for a defence of single deflation as a way of avoiding negative values of real value added.

[21] In fact, in the dual approach to computing total factor productivity (TFP), over time changes in TFP are measured as the differential between the rate of variation of the output price and that of weighted input prices. In other words, a faster decline (less marked increase) of output prices than of inputs prices, due to input savings, reflects TFP growth.

[22] The 1950s, especially since 1953, were years of rapid growth and structural change in which double deflation would make a difference over single deflation. Unfortunately lack of data prevents a solution so far. Cf. Prados de la Escosura (2003).

deflated with their own price indices) are available for industry and construction over the years 1964-1980 (Gandoy, 1988).[23] Gandoy's value added series exhibit higher real growth rates than CEN70 series since her implicit value added deflator grows less than the national accounts' deflator (biased towards raw materials and semi-manufactures).[24] This is what should be expected in a context of TFP growth, such as was the case of Spain in the 1960s and early 1970s, with output prices growing less than inputs prices, as inputs savings resulted from efficiency gains (Prados de la Escosura and Rosés, 2009).[25]

Thus, revised series for GDP have been derived for 1964-1980. Firstly, Gandoy (1988) alternative value added estimates for industry and construction (GVA^{G}_{i} and GVA^{G}_{c}) were substituted for those in official national accounts (GVA^{cen70}_{i} and GVA^{cen70}_{c}).[26] CNE70 value added figures for agriculture (GVA^{cen70}_{a}) and services (GVA^{cen70}_{s}) were kept.[27] Total Gross Value Added was reached by adding up sectors' gross value added.

$$GVA^{T} = GVA^{cen70}_{a} + GVA^{G}_{i} + GVA^{G}_{c} + GVA^{cen70}_{s} \qquad \text{(IV)}$$

GDP at market prices was derived, in turn, by adding taxes on products net of subsidies to total gross value added.

[23] Cf. also Gandoy and Gómez Villegas (1988). CNE70 used occasionally double deflation when strong discrepancies between output and inputs prices were observed, and data availability allowed it, but, in any case, never over the years 1978-1981. In the case of agriculture, real value added was properly assessed in CNE70, as the purchases of industrial and service inputs represented a small share of final output. As for services, the difficulties to produce double deflated value added series, comparable to those for agriculture and manufacturing, persisted over time.

[24] Cf. Krantz (1994).

[25] Although, fortunately, from 1980 onwards, CNE80 provided industrial value added computed through the standard double deflation procedure, there were still difficulties to obtain double-deflated value added for construction and services with an acceptable degree of accuracy. Cf. INE (1986) for a discussion of CNE80.

[26] Also van Ark (1995) chose Gandoy (1988) series over the original national accounts. Among the reasons given by van Ark for this choice are the downward bias in the growth rates of industrial production indices and its failure to adjust to the emergence of new products (and quality changes).

[27] The reasons for keeping original CNE70 gross value added for agriculture and services is exposed in footnote 23. For a discussion of the problems in measuring services' gross value added through double deflation, see Mohr (1992).

To interpolate CNE80 and CNE70^R series their gap at the overlapping year 1980 was distributed over 1964-1979 with expression (III). The reason why CNE70^R series have been accepted for the years 1964-1969, rather than distributing the difference in 1970 between CNE70^R and CNE58/64 over these years, is that CNE70^R series have been derived through double deflation, as opposed to CNE58/64 single deflation series.

CNE70^R and CNE58/64 series were, then, interpolated by distributing their gap in 1964 over 1958-1964 with expression (III).[28] CNE58 series have been accepted for the years 1954-1958.

It is worth noting that in the absence of double deflated gross value added series in CNE58/64, the *interpolation* splicing procedure provides a correction of these series that could be taken for an allowance for efficiency gains (that would not happen under the alternative *retropolation* approach). This seems particularly appropriate for the period 1959-1963, when Spain opened up to the international economy gradually filling in the technological gap (Prados de la Escosura and Rosés, 2009).

Once GDP series at current prices were obtained, the next task was to deflate them in order to obtain GDP volume series. Deflators for each CNE benchmark GDP series were also spliced through *interpolation* using expression (III).[29]

How sensitive is long-run performance to the choice of splicing method?

Figure 1a presents the GDP levels resulting from splicing national accounts through linear and non-linear interpolation (computed with expressions (II) and (III), respectively), relative to the levels derived through extrapolation (obtained with expression (I)). In Figure 1b an alternative yardstick is provided by the GDP series derived through 'hybrid' retropolation, obtained by combining the segments of official national account series that have been obtained using linear interpolation and retropolation. Actually, the 'hybrid'

[28] There is no discrepancy between CNE58 and CNE64 estimates for the period 1958-1964.

[29] The deflators resulting from using alternatively the *interpolation* and *retropolation* approaches are practically identical. This may result from the fact that Spanish national accounts only provide price variation over time, not price levels.

retropolation method is the one most frequently used, as it is the easiest to compute.[30] It can be noticed how the over-exaggeration of GDP levels cumulates over time with the exception of the late 1960s (when stabilises) and, if the 'hybrid' retropolation series are used as the yardstick (Fig. 1b), of those periods in which the series were derived through linear interpolation (1980-1986, 1995-2000, 2000-2008). It is also noticeable that there are hardly significant discrepancies between the linearly and non-linearly interpolated series.

Do GDP estimates resulting from the alternative splicing procedures provide, then, different views of Spain's economic performance over the long run? Figure 2 present the evolution of GDP at constant prices, expressed in logs, according to alternative splicing methods during the national accounts era. It can be observe that the differential between the interpolated and retropolated series widens significantly over time. Table 3 compare the resulting GDP growth rates derived by splicing national accounts alternatively with the *interpolation* and r*etropolation* approaches.

INSERT FIGURE 2 and TABLE 3 HERE

Average annual rates of variation have been computed between National Accounts benchmark years in Panel A, so the implications of alternative splicing procedures for measuring growth are highlighted. The new GDP estimates derived through the *interpolation* procedure cast higher growth over the entire time span considered than those estimates resulting from the conventional r*etropolation* method. The annual accumulated increase per person is 4.15 per cent over 1958-2008 (4.37 per cent for 1958-2000) compared with a previous figure of 3.70-3.74 per cent for the retropolated and 'hybrid' retropolated series (3.82-3.87 per cent over 1958-2000), respectively. The main discrepancies correspond to the periods 1964-1980 and 1986-1995, in which the

[30] Even de la Fuente's (2012) does it in his estimates combining 'mixed' splicing for 1986-2010 with available estimates derived through retropolation for 1955-1995. This author also adjusts GVA estimates after reconciling employment figures from EPA (Encuesta de Población Activa, active population survey) with those from the official national accounts (CNE).

interpolated series exhibit more intense growth. Conversely, the retropolated series grew faster in the early 1980s and over 1958-1964.

If we now turn to the main periods or phases of economic performance in post-1950 Spain (Panel B), it can be noticed that, in the period of rapid expansion (1958-1974) -Spain's delayed Golden Age-, the interpolated series grew faster that the retropolated ones. Conversely, during the so-called 'transition to democracy' period (1974-1986), the growth differential between the interpolated and the retropolated series widens to almost 0.8 per cent per year. Again, a favourable, though milder differential in favour of the interpolated series appears over 1986-2007. As a result, the deceleration following the exceptional growth of Spain's delayed Golden Age was not as dramatic as suggested by conventional *retropolated* estimates.

INSERT FIGURE 4

However, the differences between the results of the *interpolation* and r*etropolation* procedures appear much more dramatic when placed in a long run perspective, that is, when the spliced national accounts are projected backwards into the nineteenth century with volume indices taken from historical accounts series. This is due to the fact that most countries, including Spain, grew at a slower pace before 1950, so its per capita GDP level by mid-twentieth century determines its earlier relative position in country rankings.

Thus, the choice of splicing procedure can result in far from negligible differences in the relative position of a country in terms of per capita income over the long run. In order to illustrate this point, I have estimated Spain's relative position to France, the country with most "European" features in continental Europe (Crafts, 1984), using alternative splicing methods. In Figure 3 Spain's real income per head, as a proportion of France's (expressed in 2011 EKS dollars) is provided for alternative GDP series derived with the *retropolation* and *interpolation* approaches.[31]

[31] GDP levels in 2011 have been converted into 'international' dollars using EKS purchasing power parity exchange rates taken from the latest ICP round (World Bank, 2013).http://siteresources.worldbank.org/ICPEXT/Resources/ICP_2011.html and projected backwards with

According to the *retropolation* splicing procedure, by mid-nineteenth century, real per capita GDP in Spain would have been similar, if not superior, to that of France. If, alternatively, the relative position that results for Spain from the in*terpolation* splicing procedure represents about 80 percent of the French. When the period 1850-1913 is considered, Spain would match France's real income per head, according to the retropolated series, and reach only four-fifths if the interpolated series are employed. These proportions hardly alter if the period under comparison is extended to 1935. These striking results are confirmed for a similar comparison between Spain and Italy. Spain would have been, on average, a 15 per cent richer than Italy over 1850-1935, according to the retropolated series, but only 90 per cent, according to the interpolated series.[32] It can be conclude, then, that whatever the measurement error embodied in the *interpolation* procedure may be, its results appear far more plausible than those resulting from the conventional *retropolation* approach.[33]

Concluding remarks

A survey of the potential GDP bias from splicing national accounts has been offered on the basis of Spanish experience and an alternative *interpolation* method to the conventional *retropolation* one proposed. The bottom line is that splicing national

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GDP volume series from the spliced national accounts back to 1958 and, then, from Prados de la Escosura (2003) back to 1850. I have divided the resulting GDP series by population to derive per capita GDP estimates at 2011 EKS dollars (see a discussion of the new historical series for Spanish population in Appendix B). The French series of real GDP per head come from the Maddison Project, http://www.ggdc.net/maddison/maddison-project/home.htm, completed with data from Conference Board http://www.conference-board.org/data/economydatabase/
The levels of GDP per head derive from ICP2011.

[32] The Italian series of real GDP per head come from the Maddison Project, completed with data from Conference Board. The levels of GDP per head derive from ICP2011. Alternative estimates using Baffigy (2013) and Brunetti et al. (2011) result into an even less favourable position for Italy.

[33] Alternatively, I have carried out the exercise with the 1990 ICP benchmark estimate favoured by Maddison (Maddison Project) and the previous ICP round for 2005 used in the Penn Tables 8.0 (Feenstra et al. 2013) with similarly striking results. See Appendix C.

accounts must be handled with extreme care, especially when countries have experienced intense growth and deep structural change, as there is a risk to bias their income levels upwards and, consequently, their growth rates downwards. A systematic revision of national accounts splicing in fast growing countries over the last half a century using the *interpolation* approach would most probably reduce their initial per capita GDP levels while rise their growth with the result of a more intense and widespread catching up to the Core countries. This hypothesis provides a most interesting challenge for further research.

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Table 1

Spain's National Accounts, 1954-2013

	Benchmark Year	Coverage
CNE1958	1958	1954-1964
CNE1964	1964	1964-1972
CNE1970	1970	1964-1982
CNE1980	1980	1970-1985
CNE1986	1985/86	1964-1997
CNE1995	1995	1995-2004
CNE2000	2000	1995-2009
CNE2008	2008	1995-2013

Note: Direct estimates only refer to years after the benchmark.
Sources: IEF (1969), INE (various years).

Table 2

GDP at market prices: Alternative Estimates

(Million Euro at current prices)

	[I] CNE2008	[II] CNE2000	[III] CNE95	[IV] CNE86	[V] CNE80	[VI] CNE70	[VII] CNE64	[VIII] [(I)/(II)]	[IX] [(II)/(III)]	[X] [(III)/(IV)]	[XI] [(IV)/(V)]	[XII] [(V)/(VI)]	[XIII] [(VI)/(VII)]
1964					7360	7225	6543					1.0186	1.1044
1970				15812	15772	**15483**	**13607**				1.0025	1.0186	**1.1378**
1980				91161	**91409**	**91264**					0.9973	**1.0016**	
1985			175625	**169491**	**167615**					1.0362	**1.0112**		
1995		447205	**437787**	**419387**	413788				1.0215	**1.0439**	1.0135		
2000		**630263**	**610541**						**1.0323**				
2008	**1087788**	**1088124**						**0.9997**					

Sources: IEF (1969), INE (various years).

Table 3

GDP Growth, 1954-2013: Alternative Splicing Methods

(Annual average logarithmic rates %)

	Retropolation	'Hybrid' Retropolation	Adj. linear Interpolation	Adj. non-linear Interpolation
Panel A. National Accounts benchmarks				
1958-1964	5.82	5.82	5.35	5.35
1964-1970	6.05	6.05	6.54	6.54
1970-1980	3.40	3.40	5.00	5.00
1980-1986	1.67	1.79	1.53	1.53
1986-1995	2.92	2.92	3.63	3.63
1995-2000	3.81	4.03	4.02	4.02
2000-2008	3.04	3.04	3.04	3.04
1958-2000	3.82	3.87	4.37	4.37
1958-2008	3.70	3.74	4.15	4.15
Panel B. Economic phases				
1958-1974	6.00	6.00	6.34	6.38
1974-1986	1.61	1.67	2.43	2.38
1986-2007	3.28	3.33	3.63	3.63
2007-2013	-1.01	-1.01	-1.01	-1.01
1954-1974	5.83	5.83	6.10	6.13
1954-2013	3.37	3.40	3.75	3.75

Sources: See text and Appendix A.

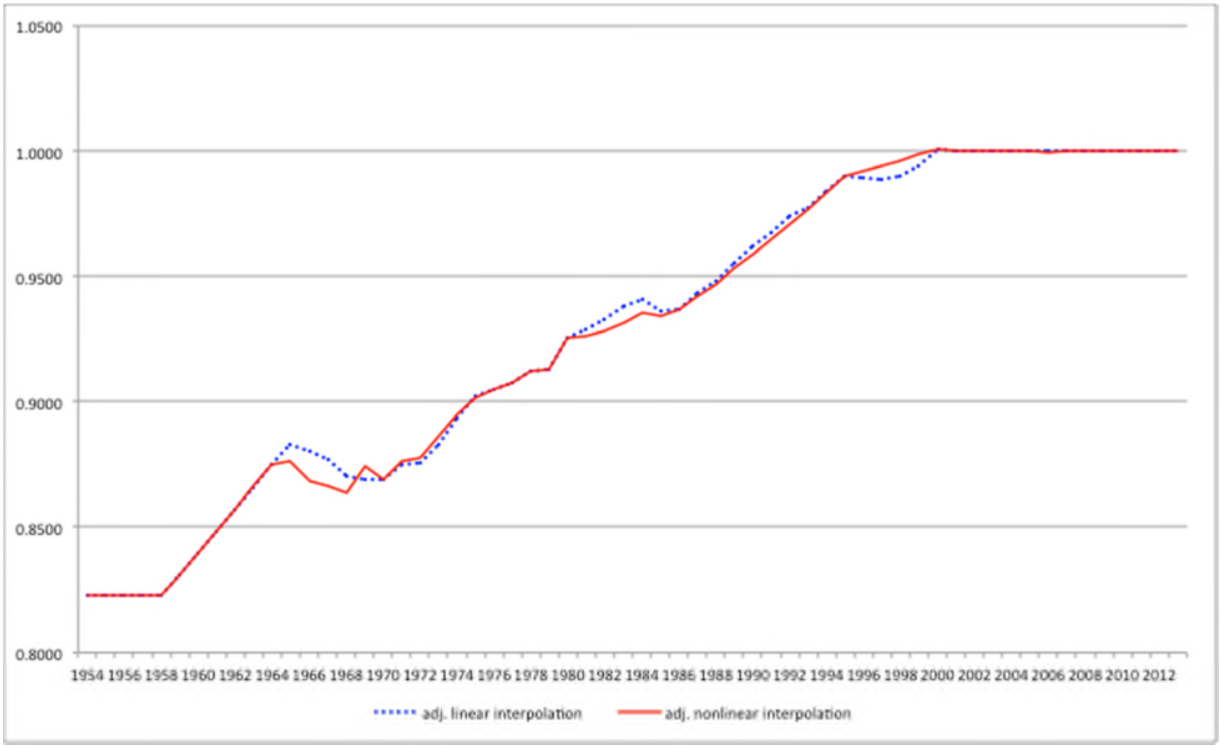

Figure 1a Spliced interpolated series relative to retropolated series, 1954-2013 (GDP_{mp} at current prices). *Sources*: Appendix A

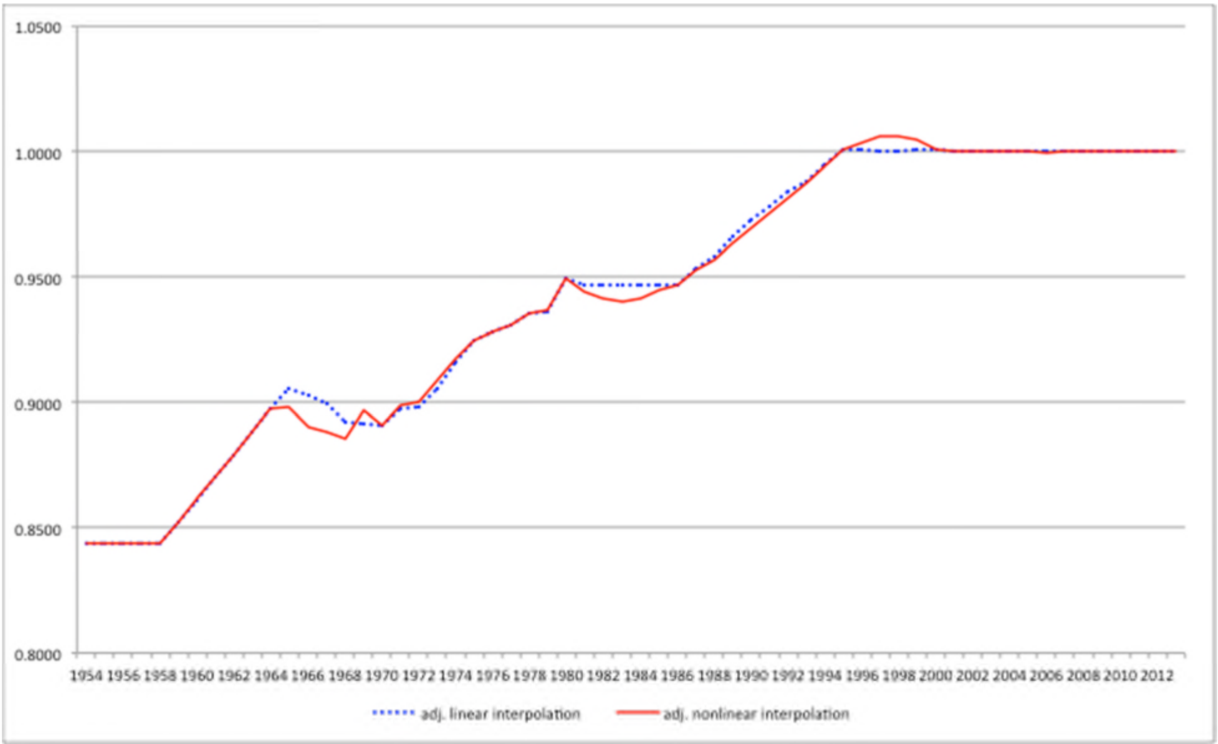

Figure 1b Spliced interpolated series relative to ‘ hybrid’ retropolated series, 1954-2013 (GDP_{mp} at current prices). *Sources*: appendix A.

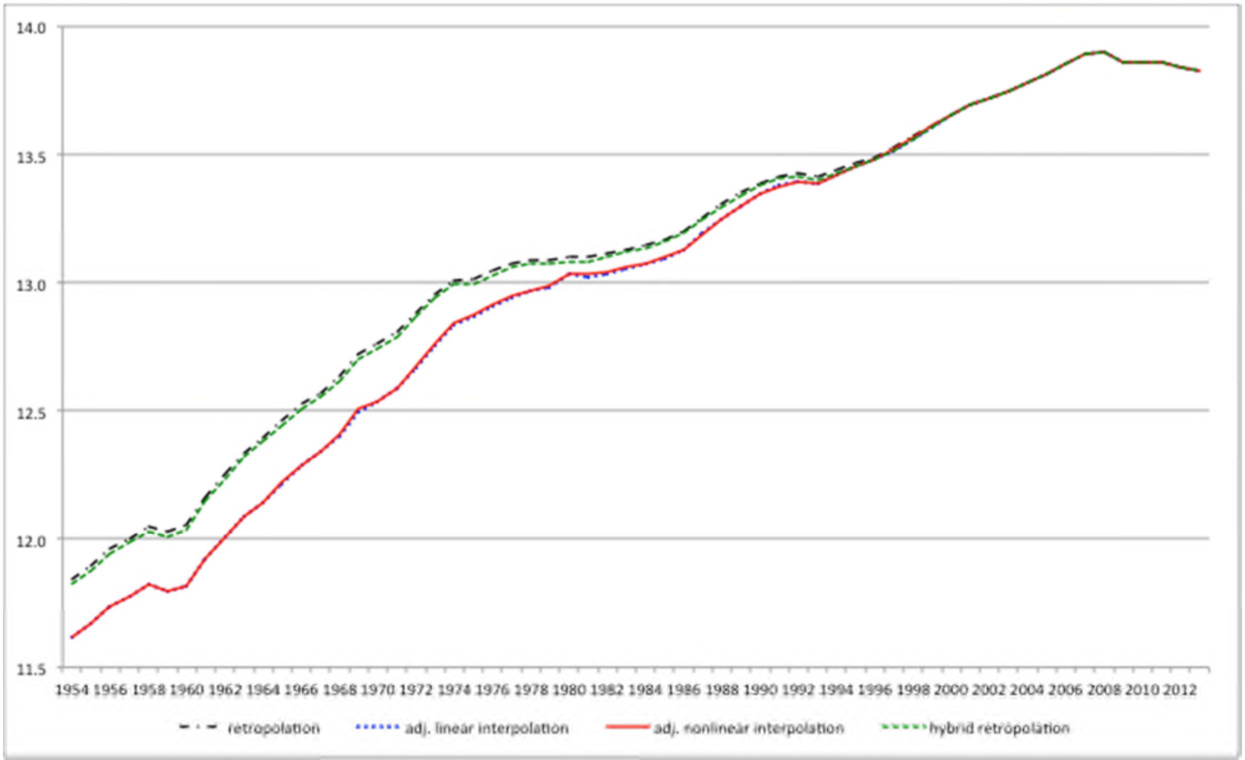

Figure 2 GDP at 2008 prices, 1954-2013: Alternative spliced series. Sources: Appendix A

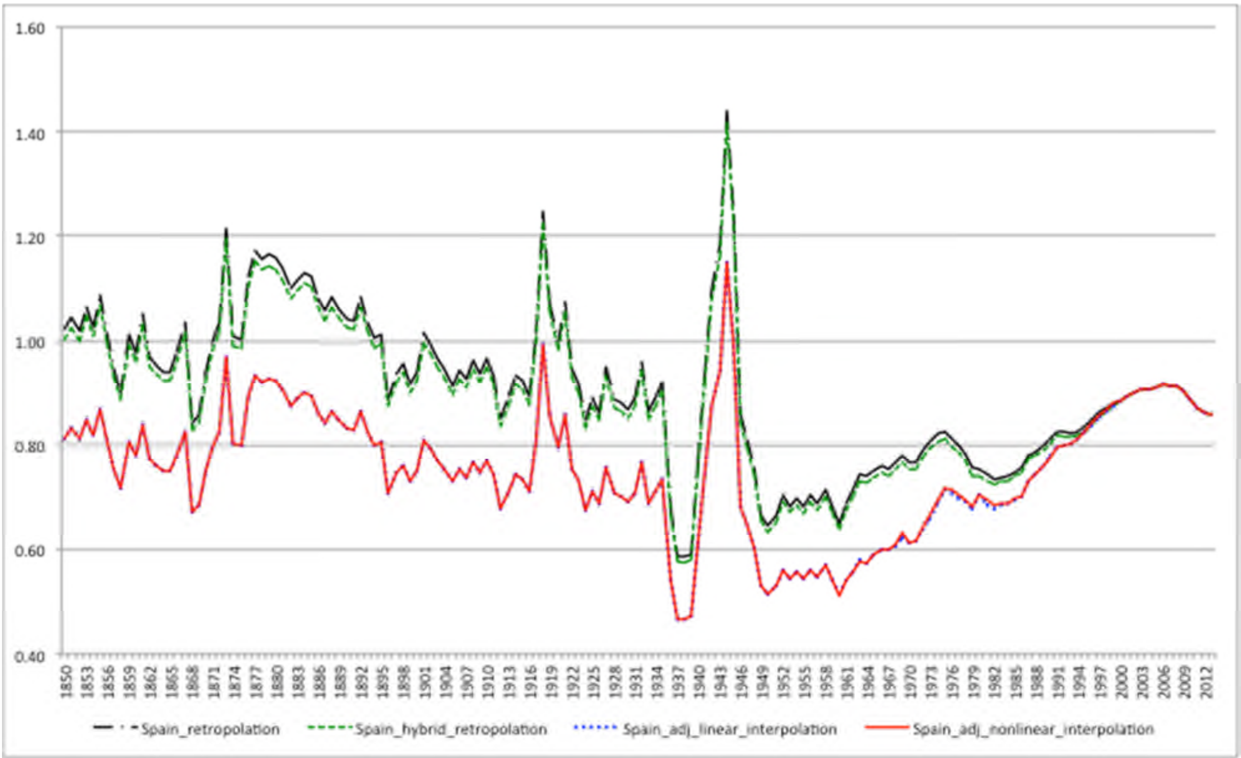

Figure 3 Spain's Relative Real Per Capita GDP (France = 1). Alternative Splicing Results (2011 EKS $). *Sources*: See text, Appendix A and Prados de la Escosura (2003).

Appendix A. GDP at Current and Constant Prices, 1954-2013: Alternative Splicing Series

Table A.1 GDP_{mp} at current prices, 1954-2013: Alternative Splicing Series (million Euro)

	Strict Retropolation	Hybrid (1) Retropolation	Adj. Linear (2) Interpolation	Adj. Nonlinear (3) Interpolation
1954	2460	2398	2024	2024
1955	2745	2676	2258	2258
1956	3153	3075	2594	2594
1957	3697	3605	3042	3042
1958	4250	4144	3497	3497
1959	4408	4298	3664	3664
1960	4534	4421	3808	3808
1961	5164	5035	4381	4381
1962	5967	5818	5114	5115
1963	7043	6868	6098	6100
1964	7952	7753	6957	6957
1965	9253	9022	8169	8106
1966	10704	10437	9421	9294
1967	12024	11723	10544	10415
1968	13476	13140	11726	11634
1969	15325	14943	13321	13402
1970	17039	16614	14803	14803
1971	19232	18751	16828	16849
1972	22568	22004	19759	19802
1973	27209	26530	24030	24106
1974	33319	32487	29764	29813
1975	39109	38133	35277	35264
1976	47061	45886	42585	42592
1977	59705	58215	54176	54185
1978	73052	71228	66622	66632
1979	85436	83303	77985	78019
1980	98756	96291	91409	91409
1981	110314	108205	102441	102162
1982	127055	125205	118535	117912
1983	144375	143038	135419	134523
1984	163053	162005	153376	152553
1985	181088	179027	169491	169177
1986	207442	205202	194271	194271
1987	231964	229458	218780	218578
1988	258250	255461	244816	244474
1989	289388	286263	276558	275890

1990	322332	318850	310074	309148
1991	353464	349647	342068	341003
1992	380690	376578	370711	369549
1993	393855	389601	385028	384580
1994	418888	414364	412326	411864
1995	451673	446795	447205	447205
1996	478977	473577	473855	475236
1997	509814	503787	503921	506896
1998	544722	539325	539493	542744
1999	583354	579662	579942	582458
2000	629907	629907	630263	630263
2001	680397	680397	680397	680643
2002	729258	729258	729258	729219
2003	783082	783082	783082	782986
2004	841294	841294	841294	841168
2005	909298	909298	909298	909108
2006	985547	985547	985547	985231
2007	1053161	1053161	1053161	1053208
2008	1087788	1087788	1087788	1087788
2009	1046894	1046894	1046894	1046894
2010	1045620	1045620	1045620	1045620
2011	1046327	1046327	1046327	1046327
2012	1029279	1029279	1029279	1029279
2013	1022988	1022988	1022988	1022988

Notes:

1) Includes official INE interpolation for 1981-85 and 1995-2000 (including 1995 methodological upward adjustment)

2) Includes official INE interpolation for 1981-85 and 1995-2000 (including 1995 methodological upward adjustment) plus double deflation correction

3) Includes 1995 methodological upward adjustment plus double deflation correction

Sources: See Text

Table A.2 GDP_{mp} at 2008 prices, 1954-2013: Alternative Splicing Series (million Euro)

	Strict Retropolation	Hybrid (1) Retropolation	Adj. Linear (2) Interpolation	Adj. Nonlinear (3) Interpolation
1954	139271	136789	111018	111018
1955	146500	143890	116781	116781
1956	157001	154204	125152	125152
1957	163715	160797	130503	130503
1958	171097	168048	136388	136388
1959	167851	164860	133189	133182
1960	171798	168737	135699	135683
1961	192139	188716	151073	151047
1962	210028	206285	164384	164347
1963	228420	224350	177963	177912
1964	242546	238224	188041	188041
1965	257909	253313	202629	202932
1966	276103	271183	217760	217558
1967	288033	282901	229448	229173
1968	307546	302066	243122	244327
1969	335040	329071	266979	271038
1970	348713	342499	278381	278381
1971	364685	358187	292731	293376
1972	393978	386958	318545	319887
1973	424260	416700	347193	349222
1974	446802	438841	375943	378295
1975	449199	441195	387385	389334
1976	463902	455636	404567	407632
1977	477822	469308	417385	420229
1978	484743	476106	427422	429573
1979	484069	475444	434895	436058
1980	490063	481331	459011	459011
1981	488846	480482	451099	456735
1982	494793	488007	458164	461675
1983	503726	498838	468333	470067
1984	512791	506157	475204	476896
1985	524660	519379	487617	488248
1986	541851	535999	503221	503221
1987	571908	565731	535866	535358
1988	601041	594550	568036	566880
1989	630058	623253	599712	598053
1990	653894	646831	627126	624928
1991	670525	663283	646483	644615

1992	676762	669453	656138	654914
1993	669783	662549	653697	652952
1994	685744	678337	673764	673658
1995	704653	697043	697682	697763
1996	722269	714126	714545	716344
1997	750868	741992	742189	746636
1998	782866	775110	775351	780320
1999	816927	811757	812149	815629
2000	852679	852679	853161	853161
2001	883967	883967	883967	884245
2002	907925	907925	907925	908129
2003	935974	935974	935974	936189
2004	966481	966481	966481	966693
2005	1001116	1001116	1001116	1001392
2006	1041924	1041924	1041924	1041971
2007	1078174	1078174	1078174	1078322
2008	1087788	1087788	1087788	1087788
2009	1046100	1046100	1046100	1046100
2010	1043995	1043995	1043995	1043995
2011	1044520	1044520	1044520	1044520
2012	1027374	1027374	1027374	1027374
2013	1014813	1014813	1014813	1014813

Notes:
1) Includes official INE interpolation for 1981-85 and 1995-2000 (including 1995 methodological upward adjustment)
2) Includes official INE interpolation for 1981-85 and 1995-2000 (including 1995 methodological upward adjustment) plus double deflation correction
3) Includes 1995 methodological upward adjustment plus double deflation correction

Sources: See Text

Appendix B. A New Historical Series for Spain's Population

Spanish Statistical Institute (INE) provides yearly series of 'resident' population from 1971 to 2012. INE presents also annual series of 'de facto' population for 1900-1991 in which figures for census benchmark years are linearly interpolated (See Nicolau, 2005). This series are collected and completed back to 1858 by Nicolau (2005). More recently, Maluquer de Motes (2008) constructed yearly estimates of 'de facto' population for 1850-1991 and spliced them with 'resident' population for 2001. In order to do so, Maluquer de Motes started from census figures at the beginning of each benchmark years adding up annually the natural increase in population (that is, subtracting deaths from births) plus net migration (that is, immigrants less emigrants). I have followed Maluquer de Motes approach but introduced some modifications. Thus, I have accepted census benchmark years' figures and Sündbarg (1908) estimate for 1850 and obtained the natural increase in population with Nicolau (2005) figures for births and deaths from 1858 onwards, completed for 1850-1857 with Sündbarg (1908), reproduced in Maluquer de Motes (2006: 145), net estimates at decadal averages equally distributed.[34] My main departure from Maluquer de Motes has been with regards to net migration for which I have accepted Sánchez-Alonso (1995) estimates for 1882-1930, completed back to 1850 and forth to 1935 with statistical evidence from Spanish and main destination countries' sources.[35] For

[34] I have used the average birth and death rates in 1858-1860 for the years 1850-1857, except in the case of 1855-1856 for which the death rate (45 per 1000) estimated for 1855 as a consequence of cholera epidemics by Pérez Moreda (1980: 398) has been used. I have also used the average of birth and death rates in 1870 and 1878-1880 for the years 1871-1877 in which data on total births and deaths are missing.

[35] For 1850-1881, Figures of Spanish immigration in Argentina, Uruguay, Brazil and the U.S.A., provided by the recipient countries' official statistics were completed with emigration to Cuba in 1860-1861 from *Anuario(s) Estadístico(s)* that was assumed to remain constant over the period. Emigration to Algeria was derived from Spanish arrivals in Alger and Oran for the years 1872-1881, while the figures for 1850-1871 were estimated under the arbitrary assumption that the share of emigrants who remained in Algeria after one year of residence was similar to the one over the period 1872-1881 (25 percent). Estimates for returned migration was computed by assuming that the average returns from America for 1869-73 were acceptable for 1850-1868 while 92 percent of emigrants to Algeria returned home within the first year. A consistency check of the yearly migration data was performed using the migration balances from population censuses

the years of the Civil War (1936-1939) and its aftermath (1940-1944) I have accepted Ortega and Silvestre (2006) gross emigration estimates for 1936-1939, assuming no immigration during the war years, and distributed equally their return migration estimates for 1940-1944 (that I raised to 190,000 to allow for underestimation), while assuming no gross emigration during World War II.[36]

Splicing of population estimates also differs from Maluquer de Motes' procedure. Instead of linearly distributing the difference between the estimated population by forward projection of the initial census benchmark figure for the year of the next census benchmark, and the observed figure at the new census (presumably Maluquer de Motes used expression (II)), I have projected every pair of adjacent censuses benchmark year figures back and forth with the natural increase in population plus net migration. Then, I have used expression (III) to derive a compromise population estimates of the inter-census years in which the closer benchmark year gets a higher weight. Lastly I have spliced the nonlinearly interpolated series for 'de facto' population for 1850-1970 with the 'resident' population series from 1971 onwards to get a single series. Fortunately, the difference between the two series at 1971 is negligible, 34.211 and 34.216 thousand inhabitants, and the average ratio between the resident and de facto population over 1971-1991 is 0.9956 with a coefficient of variation of 0.0048. The concept of 'resident' population makes more sense at the time of high population mobility across national boundaries while the improvement in the accuracy of registration procedures make the estimates much more reliable (Maluquer de Motes (2008: 148-149). The reason to choose 'resident' over 'de facto' population is to keep consistency with Spanish official population statistics (used also for national accounts) employ 'resident' population.

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along the lines described in Sánchez-Alonso (1995). Data for returned migration from America, 1869-1881, was taken from Yáñez (1994), p. 120. Data on migration to Algeria over 1850-1881 comes from Vilar (1989).

[36] Ortega and Silvestre (2006) consider the 162,000 net migration figure during 1940-1944 grossly underestimated. Pérez Moreda (1988: 418) suggested a maximum permanent exile of non more than 190,000 people, a figure below the 200,000 provided by Tusell (1999) and much lower than a post-Civil War exile estimate (300,000) (Tamames, 1973).

Appendix C. Spain's Relative Position, 1850-2013 (France = 1). Alternative Estimates

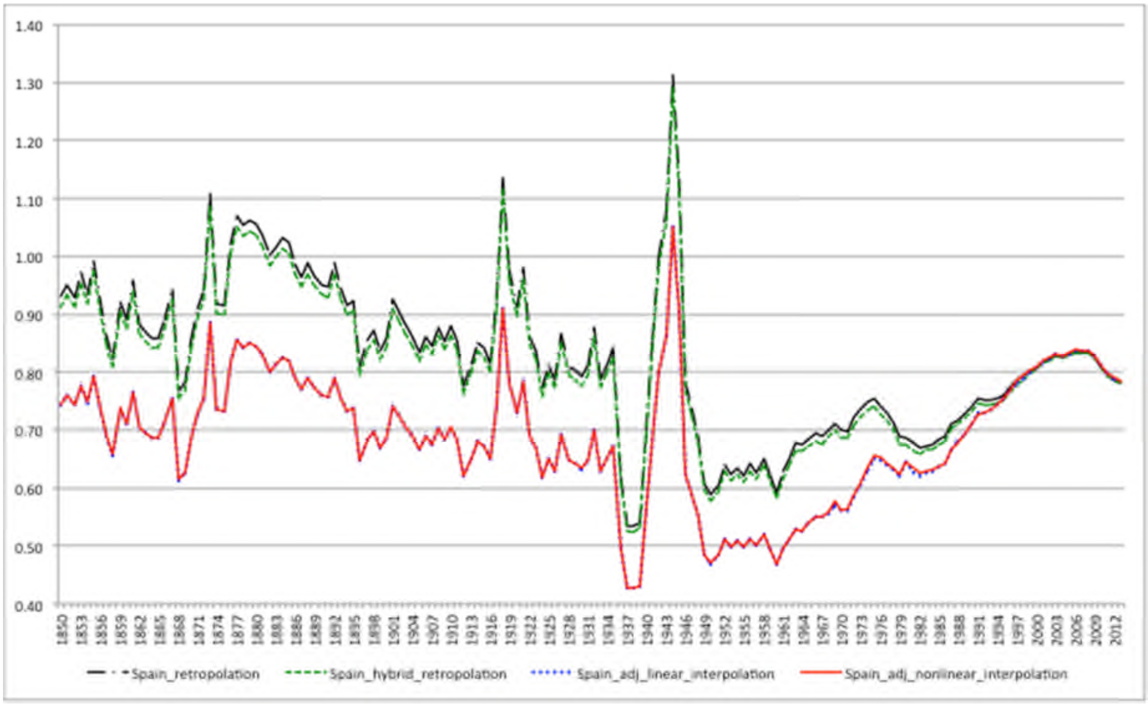

Figure C-1 Spain's Relative Real Per Capita GDP (France = 1). Alternative Splicing Results (1990 Geary-Khamis $). *Sources*: See text, Appendix A and Prados de la Escosura (2003).

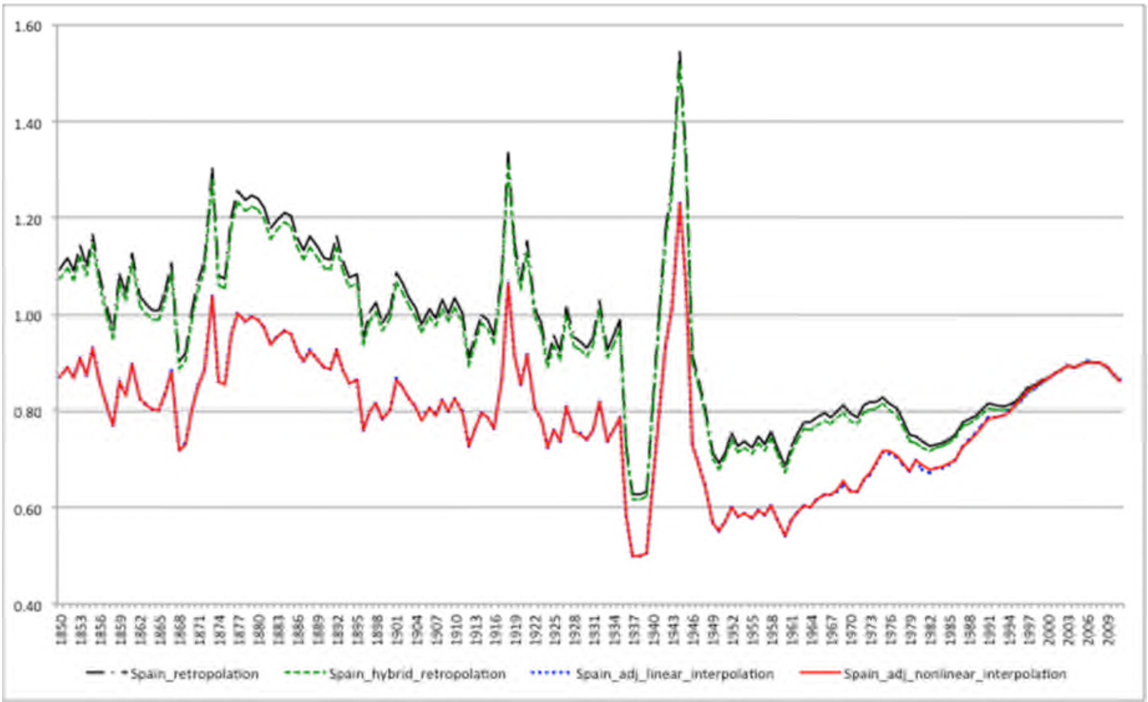

Figure C-2 Spain's Relative Real Per Capita GDP (France = 1). Alternative Splicing Results (2005 EKS $). *Sources*: See text, Appendix A and Prados de la Escosura (2003).